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A Framework for Assessing Reflective Writing Produced Within the Context of Computer Science Education

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ABSTRACT: Reflective writing is known to be an effective activity to increase students' learning. However, there is limited literature in reflective writing assessment criteria in the context of computer science (CS) education. In this paper, we aim to explore a meaningful reflective writing assessment characteristics. That has been used to assess reflective text by CS educators. This paper has two contributions: (a) we developed a Reflective Writing Framework (RWF) for the main criteria has been used to assess reflective text in CS education from the findings of a semi-structure questionnaire; (b) the RWF was tested empirically using a pilot test of the manual annotation used to modify the framework. This analysis resulted in an inter-rater reliability of 0.78 being achieved. The overall goal of this research is to develop a Learning Analytics (LA) tool which can automatically detect the categories of the RWF present in a text to assess the student authors' reflective writing in relation to CS.

Keywords: Reflective Writing, Computer Science, Reflection, Reflection Detection, Reflective Writing Analytics, Learning Analytics

1 INTRODUCTION

Learning Analytics (LA) is gradually becoming one of the pivotal aspects of educational technology. This paper investigates an LA tool that supports reflection by analyzing and providing feedback on reflective writing (RW). RW can support students to gain awareness of their learning processes. In terms of Computer Science (CS), "reflection is worth encouraging, for its indirect effect on the technical skills and knowledge which are our ultimate purpose in teaching computer science" (Fekete, Kay, Kingston, & Wimalaratne, 2000). Technical skills are at the core of CS, and these center around formulating problems and their solutions. Since reflection is a metacognitive process, it can only be assessed indirectly - through written or verbal forms. Analyzing RW manually makes giving students feedback a challenging and time-consuming task. Automated feedback can better support the students in terms of providing timely analyses. LA tools have the goal of supporting reflection – specifically, by analyzing students' reflective texts. To design an LA tool for RW, there is a necessity either to adapt an existing methodology or to develop a new framework for this purpose (Gibson et al., 2017). This study aims to develop a RW Framework (RWF) for CS education to develop an LA tool for RW. We focus on the following research questions: 1) what are the characteristics of RW within CS education? And 2) what are the indicators which can be used to assess RW levels as they occur in CS education?

2 RELATED WORK

Reflective activities that have been used recently investigated RW in CS education (Alrashidi, Joy, & Ullmann, 2019; George, 2002; Stone & Madigan, 2007) as they have in other disciplines such as social and health sciences. However, the literature on RW in CS education is limited. For instance, George (2002) and Fekete et al. (2000) investigated using the reflective journal in terms of benefits to the students in an undergraduate programming course. Both studies noted that reflective journals were beneficial to get students to reflect on their software development processes as it is part of their learning outcome. Moreover, in accordance with the LA tool for reflection in CS education, Dorodchi et al. (2018) implemented an activity based on the CS course with periodic reflection by applying Kolb's learning model. They validated the result of student reflection through the LA classification model. It concluded that including reflection as a feature could improve the accuracy and time of their classification model. However, there is a difficulty for students to reflect effectively on their own understanding. Moskal and Wass (2019) developed an approach for educators to encourage students to think about their software development steps through a series of sessions. They found that the approach was beneficial for both students and educators. However, Grossman (2009) mentioned that a number of students did not understand what they are expected to reflect on due to lack of guidance. Grossman's (2009) findings provide reasoning for the study conducted by George (2002) that found reflective journal as not widely accepted by students and/or educators in CS education. The RWF developed here is a guideline for students to determine the main elements on which they are expected to reflect, and for educators on assessing their students' RW.

3 THE RWF

Semi-structured questionnaires explored perspectives of 6 HE experts (Exp.) –selected based on their breadth of academic skills in CS and their knowledge of reflection– on RW levels, and the indicators they use to assess RW in CS education. A thematic analysis of the responses resulted in three codes for levels of reflection: 1) non-reflective, 2) reflective, and 3) critically reflective; and seven codes for indicators summarized as follows.

First, the **descriptive**: two experts used similar words in their definitions of such indicators. Exp. A stated that: “students merely **describe** what they have done ... without any examples.” Exp. C used the word “**listing**” instead stating that “I would often see simple summaries of lesson content, or **listings** of topics covered that I would class as **non-reflective**”. This means that “**non-reflective**” texts are superficial descriptions of situations. Second, the **understanding**: all the experts characterized it as bordering on the reflective level. For example, Exp. E defined this indicator as, “when students **identify** their **understanding** of competencies ... [RW] has been reached.” Accordingly, the understanding indicator characterizes both the non-reflective and the reflective levels, per the context. Third, the **feeling**: the experts argued that the reflective level applies when the writer can identify their own thoughts and feelings. For example, Exp. C stated that “I would look for evidence of what the students previously **thought** or **felt** on whether that had worked or not.” This means that the feeling indicator in the proposed framework can be either at the reflective or critically reflective level. Fourth, **reasoning**: they argued it occurs when a writer explains a situation/issue by providing examples/causes. For instance, students would “clearly **explain** their process, what worked, what didn't” (Exp. D), and “**provide examples**” (Exp. G), and/or “**analysis** of problems and [their solutions]” (Exp. C). Fifth, **perspective**: this could be detected when “Students share **personal** thoughts and

connect with **other** thoughts” (Exp. G), and giving “evidence of **re-evaluation** [due to] feedback from **others**” (Exp. D). Both experts emphasized that perspective takes into consideration others’ perspectives. Exp. D summarizes it as students’ ability “to **connect** the topic in question to wider applications in the **discipline**, their **community**, or the **world**”.

Sixth, the significance of the **new learning indicator** was clearly emphasized by the panels. The experts commented that they search for evidence of learning. For example, Exp. H mentioned that the student must show evidence of what has been learnt in terms of personal and professional skills by “connecting what we have learned and the skills ... gained to our own personal or professional developments”. Lastly, **future action**: the panel of experts commented that they search for evidence of outcome when assessing RW. Exp. C expected the student to show they had achieved a deeper understanding of the problem they were engaged with, as a result of producing the RW, in terms of *cognition* by having “ a **deeper** understanding of what they have learnt”, *metacognition* by being “**better** able to manage their **own learning** and **development** once they leave formal education,” and *socially* with the ability “to work **better** in a team by identifying and owning their own weaknesses, and sharing their successes.”

Table 1 shows all the indicators and levels of our RWF which is consistent with the literature on RW and on reflection theories, especially in terms of the levels defined by Wong, Kember, Chung, and Yan (1995) and the reflection indicators defined by Ullmann (2019).

Table 1 Levels and Indicators of the RWF for CS

Reflective levels	Indicators
Non- Reflective	Descriptive: the writer reports a fact from experience and/or materials
	Understanding: the writer understands and/or analyses the experience.
Reflective	Feelings: the writer identifies and/or analyses their own thoughts and feelings.
	Reasoning: the writer explains the experience by giving reasons.
Critically	Perspective: the writer shows awareness of alternatives.
Reflective	New learning: the writer integrates and/or describes new learning
	Future action: the writer intends and/or plans to do something in the future.

4 VALIDATION OF THE RWF

A manual annotation aimed to produce a final version of the framework through manual reviews and using this activity as a basis for an iterative cycle of framework development. The dataset consisted of 30 RW documents –split into 360 sentences– from 30 computer science students in module CS310 Computer Science Project all relating to a 3rd-year project undertaken during 2013–2016 academic years. The data were collected by the CS Department at the authors’ university as part of its normal assessment process and then provided to the researchers fully anonymized. Four pilot studies were conducted October 2018–May 2019 to produce reliable guidelines based on the RWF and developed via the raters’ comments and suggestions.

In Table 2, the first pilot study, four independent raters applied the initial RWF to the annotation of 20 sentences and then explained their ratings. From this, we recognized some ambiguity in the reflection indicators as formulated in the guidelines given to the raters. In the second pilot study, the three independent raters applied the modified RWF to 40 random sentences. The modified RWF enabled them to reach a consensus regarding the three levels and the seven indicators. Some minor

areas of the RWF guidelines were then refined. In the third and fourth pilot studies, two independent raters applied the RWF as framed after improvements. A kappa statistic (k) used to determine the inter-rater reliability and adjust for the possibility of a chance agreement between the coders. The inter-rater reliability of 0.87 and 0.78, respectively, which was substantial to almost perfect agreement (Landis & Koch, 1977).

Table 2: The inter-rater reliability computed for each iteration of the RWF during the four pilot tests

Date of the pilot test	#iteration	Sample	# raters	k
October 2018	1	20	4	0.52
January 2018	2	40	3	0.73
March 2019	3	100	2	0.87
May 2019	4	200	2	0.78

5 CONCLUSION AND FUTURE WORK

This research has answered two research questions that explored the characteristics of RW to identify the assessment indicators and the levels relating to RW in CS education. Based on the thematic analysis of the questionnaire, the RW framework was proposed; this has three levels and seven indicators to assess RW produced in the context of CS education. The future work will be using the findings to produce a labeled dataset to use it to develop an LA tool. That will automate RW analysis based on machine learning and rule-based approaches for determining the features of RW.

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